BEFORE THE

ILLINOIS COMMERCE COMMISSION

COMMONWEALTH EDISON COMPANY	**)**	
	)	
Verified Petition to Determine the Applicability of	**)**	
Section 16-125(e) Liability to Events Caused By the	**)**	**ICC Docket No. 11-0588**
Summer 2011 Storm Systems	**)**	

DIRECT TESTIMONY AND EXHIBITS

OF

GEORGE E. OWENS, P.E.

ON BEHALF OF

THE OFFICE OF THE ATTORNEY GENERAL

STATE OF ILLINOIS

JANUARY 26, 2012

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I. QUALIFICATIONS

Q: PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A: My name is George E. Owens. I am employed by Downes Associates, Inc. ("DAI"). My business address is 2129 Northwood Drive, Salisbury, Maryland 21801.

Q: WHAT IS YOUR PROFESSIONAL BACKGROUND?

A: I joined DAI in 1974 and served in the capacity of Project Engineer until 1980. For the past thirty-two years, I have served as President of DAI and as DAI's Chief Power Engineer. Throughout this period, my duties have included analyzing and designing high voltage electrical distribution and transmission facilities, substations, generating plants, supervisory control and data acquisition ("SCADA") systems, metering, and relay control systems. Additionally, for the past ten years, I have served as the official representative within the PJM Interconnection ("PJM") Regional

Transmission Organization ("RTO") for several municipally-owned electrical utilities. I am a member of PJM's Planning Committee, Transmission Expansion Advisory Committee, Markets and Reliability Committee, and Members Committee. During this same time period, I have served as a member of numerous PJM Working Groups and Task Forces focusing on RTO reliability, transmission planning, and new generation interconnection. I also served for two years on the Mid-Atlantic Area Council ("MAAC") Administrative Board.

Q: PLEASE DESCRIBE YOUR EDUCATIONAL BACKGROUND AND PROFESSIONAL QUALIFICATIONS.

A: I received a Bachelor of Engineering Science Degree in Electrical Engineering from the Johns Hopkins University in 1969, a Master of Science Degree in Physical Oceanography from Texas A&M University in 1971, and I completed two additional years of graduate study in Coastal and Ocean Engineering within the Civil Engineering Department of Texas A&M University. In 1974, I graduated from the U.S. Army Corps of Engineers Basic Engineering Officer Training program at Ft. Belvoir, Virginia. In addition, I have taken numerous professional development courses in electrical metering, electrical short circuit analysis, and electrical system operation. I am a registered professional engineer licensed in seventeen states including the State of Illinois and the District of Columbia. A complete description of my professional qualifications is attached to this testimony.[1]

Q: HAVE YOU BEEN RETAINED IN THIS MATTER?

[1] Exhibit GEO-1 (George E. Owens Professional Qualifications)

A: Yes. I have been retained as an expert witness in this proceeding by the Office of the Attorney General, State of Illinois.

Q: HAVE YOU PREVIOUSLY TESTIFIED AS AN EXPERT WITNESS BEFORE A PUBLIC UTILITY REGULATORY AGENCY?

A: Yes. I have provided expert testimony before the District of Columbia Public Service Commission, the Maryland Public Service Commission, and the Delaware Public Service Commission. In addition, I have provided testimony to the Federal Energy Regulatory Commission.

Q: ARE YOU FAMILIAR WITH THE COMMONWEALTH EDISON COMPANY?

A: Yes, I am familiar with the Commonwealth Edison Company ("ComEd"). ComEd is an electric distribution company serving the northern region of the State of Illinois and the City of Chicago. It is a wholly-owned subsidiary of Exelon, a publicly traded energy company that in addition to ComEd, owns the Philadelphia Electric Company which serves the southeastern region of the State of Pennsylvania, and the City of Philadelphia. During the week of December 5, 2011, I performed field inspections of numerous areas within ComEd's Illinois service territory that were directly impacted by the storms which occurred during the summer months of 2011. These field inspections were conducted with the Attorney General's Office within the Cities of Elmhurst, Evanston, Highland Park, Lake Forest, Park Ridge, Rockford, Rolling Meadows and Villages of Arlington Heights, Glenview, Morton Grove, Niles, and Schaumburg.

Q: YOUR INSPECTION OCCURRED SEVERAL MONTHS AFTER THE STORMS THAT ARE THE SUBJECT OF THIS DOCKET. WHY DO YOU BELIEVE THAT YOUR AFTER-THE-FACT INSPECTION CAN SHOW THE CONDITION OF COMED'S SYSTEM *BEFORE* THE STORMS?

A. The majority of the overhead distribution circuits that we inspected were clearly facilities that had been in service for decades. I would estimate that the average age of most of these facilities is forty years. The observed wires, poles, transformers, fuses, and switches had obviously been in service for many years before the referenced storms occurred. In addition, the lack of adequate vegetation management that was observed had obviously occurred over a number of years as evidenced by mature tree growth, again clearly predating the summer 2011 storms.

Q: HAVE YOU REVIEWED ANY OTHER MATERIALS TO FURTHER FAMILIARIZE YOURSELF WITH THE COMED SYSTEM?

A. Yes. I have reviewed testimony filed by ComEd and numerous data request responses provided by the Company as well as photographs supplied by the Office of the Attorney General in the following cities: Plainfield and LaGrange, IL

II. CASE OVERVIEW

Q: WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY?

A: I have been asked by the Office of the Attorney General, State of Illinois, to review prior filings in this proceeding and offer my professional opinion and guidance to this Commission on whether the outages experienced in the ComEd service territory in the summer of 2011 were caused by "unpreventable damage due to weather." My testimony focuses on three areas of concern: vegetation management, age of facilities, and system modernization.

Q: ARE YOU FAMILIAR WITH THE EVENTS LEADING UP TO THE INITIATION OF THESE PROCEEDINGS BY THE COMMISSION?

A: Yes. During the summer of 2011, ComEd and its customers experienced several extended outages, both during storm and non-storm events. This proceeding specifically involves the Petition For Waiver filed on August 18, 2011, with ComEd requesting that it be relieved of liability to its customers for damages resulting from outages of more than 4 hours, affecting more than 30,000 customers, occurring after several summer storms in 2011.

Q: HAVE YOU REVIEWED THE DATA REQUESTS SUBMITTED TO COMED?

A: Yes. I have reviewed the data requests submitted to ComEd by the Commission and ComEd's responses to those data requests. I have also reviewed ComEd's responses to Attorney General data requests, storm reports, and its Part 411 reliability reports filed with the Commission.

III. RECOMMENDATIONS

Q: BASED ON YOUR REVIEW OF THE MATERIALS IN THIS MATTER AND YOUR PROFESSIONAL EXPERIENCE, HAVE YOU FORMED AN OPINION ABOUT WHETHER THE SUMMER 2011 OUTAGES SHOULD BE TREATED AS "UNPREVENTABLE DAMAGE DUE TO WEATHER EVENTS OR CONDITIONS?"

A: Yes. I have identified three areas of concern which I believe contributed to the widespread and extended outages last summer. They are vegetation management practices, certain distribution system equipment issues, and deployment of system modernization technologies. The condition of ComEd's system indicates to me that the outages resulting from the summer storm were aggravated and extended due to the conditions I detail below. If ComEd had made changes related to these areas as detailed below, it is my professional opinion that service quality for its customers and distribution system reliability would have been dramatically better, and a significant portion of the outages could have been avoided or shortened in duration.

A. Vegetation Management Practices

Q: DO YOU HAVE ANY OBSERVATIONS OR RECOMMENDATIONS REGARDING COMED'S VEGETATION MANAGEMENT PRACTICES?

A: Yes I do. ComEd must adopt consistent and sufficient tree trimming programs that conform to recognized national standards, state laws, and utility best practices. If it does so, ComEd should experience a large reduction in customer service interruptions and long duration outages due to trees and other intrusive vegetation. As revealed by the previously referenced field inspections of ComEd distribution circuits as well as meetings with numerous officials of cities served by ComEd,[2] the tree trimming practices employed by ComEd have been inconsistent and inadequate to effectively deal with the high density of tree cover within much of its service territory. Because of the extent of overhead distribution circuits within the ComEd service territory, ComEd must implement consistent tree trimming programs that maintain proper

[2] Cities of Elmhurst, Evanston, Highland Park, Lake Forest, Park Ridge, Rockford, Rolling Meadows and Villages of Arlington Heights, Glenview, Morton Grove, Niles, and Schaumburg

operational clearances between its energized conductors and nearby vegetation. My inspection revealed that such clearances are not consistently maintained within ComEd's service territory, and the resulting growth aggravated the outages experienced during storms last summer.

Q. **WHAT SHOULD BE DONE TO PROPERLY MAINTAIN VEGETATION CLEARANCES?**

A. As an initial matter, ComEd should be uniformly maintaining clearance distances between the energized portions of its distribution system and adjacent vegetation that conform to guidelines found in The National Electric Safety Code (the "NESC"). The NESC recommends 9.07 feet of horizontal clearance and 9.57 feet of vertical clearance between 69 KV conductors and grounded surfaces. The NESC guidelines recommend 7.9 feet of horizontal clearance and 8.4 feet of vertical clearance between 34 KV conductors and grounded surfaces, and 7.5 feet of horizontal clearance and 8 feet of vertical clearance between 12 KV conductors and nearby grounded surfaces.[3] These clearance guidelines represent minimum distances that should be maintained between the energized conductors and adjacent grounded surfaces for each of the respective voltage classes. Trees in proximity to energized overhead primary conductors can act as grounded surfaces when saturated with moisture from heavy rains. Contact of bare primary conductors with grounded surfaces causes short circuits to occur, resulting in electrical outages. Wet tree limbs can also cause phase-to-phase short circuits to occur as well as the phase-to-ground faults previously described. Trees adjacent to primary electric lines must be trimmed enough during

[3] Exhibit GEO-2 (Table 234-1, The National Electric Safety Code)

each tree trimming cycle to ensure that tree limbs do not grow back within such clear zones during the time periods between trimmings.[4] In addition, the persistent danger of overhead limbs falling on energized conductors during both winter and summer storm events suggests that the entire vertical space above energized conductors be cleared as well. To not clear existing tree canopy above overhead power lines is to invite worsened electrical system damage and outages when heavy limbs fall upon aerial power lines. The added weight of moisture-ladened foliage from heavy rains in the presence of heavy winds often causes the sagging or breaking of tree limbs, bringing them into unwanted contact with energized conductors below.

Q. **DO YOU KNOW WHAT VEGETATION GUIDELINES COMED APPLIES TO ITS VEGETATION MANAGEMENT**?

A. ComEd's publicly stated vegetation management practice indicates trimming requirements that provide 10 feet of clearance between energized conductors and surrounding trees. This practice complies with the NESC's clearance guidelines and is consistent with clearance requirements established by numerous other states.[5]

Q. **DID YOU SEE THESE VEGETATION MANAGEMENT PRACTICES APPLIED CONSISTENTLY IN THE AREAS YOU INSPECTED**?

A. No. It was clear to me that ComEd's vegetation management was not applied in a consistent and uniform manner.[6] The field inspections I performed revealed mostly well-maintained clear zones around energized conductors along public streets and highways. Unfortunately, the same cannot be said for primary overhead lines along

[4] Exhibit GEO-3 (California Regulations for Clear Zones)
[5] Exhibit GEO-4 (OLR Research Report - Utility Tree Trimming in Other States)
[6] Exhibit GEO-5 (ComEd's Report for Park Ridge)

alleys and residential back property lines. Inspections of these areas in the cities previously referenced revealed years of vegetation management neglect with some areas suggesting a virtual abandonment of rights-of-way and related vegetation management by ComEd. Entanglements from trees in these areas have reached the stage of envelopment of primary circuits, secondary service conductors, and attached communication cables.[7]

Q. **WHAT HAPPENS WHEN WIND AND RAIN STORMS HIT AREAS WITH THIS TYPE OF VEGETATION GROWTH?**

A. When storm winds impact trees in these areas, the resultant damage to ComEd's distribution circuits will often be extensive. When such damage is extensive, the restoration time required to clear debris and rebuild circuits is often counted in days, not hours. Winds that would not affect service in properly trimmed areas can cause extensive and lengthy outages in areas where the trees have been allowed to grow so close to distribution conductors and other lines on the distribution poles.

Q. **DOES ADHERENCE TO VEGETATION MANAGEMENT GUIDELINES AFFECT OUTAGE SYSTEM OPERATION?**

A. Adherence to proper vegetation management guidelines ensures a proper combination of public safety and system reliability. An electric utility with an overhead system such as ComEd must be concerned with the continual operation of its high voltage system, with the safety of its operating personnel, and with the overall safety of the public at large. Safety is paramount. This is the reason for the existence of standards such as the NESC. Tree contact with energized high voltage conductors is by its very

[7] Exhibit GEO-6 (Drawing 3100 and 3101)

nature an unsafe condition. Contact of energized conductors with any grounded surface can lead to system outages, personal injury, or death. It also must be remembered that in the aftermath of major storms in areas with dense forestation, the result is often a tangled mass of downed limbs, trees, conductors, and poles. Untangling such masses of debris and damaged electrical facilities is an extremely dangerous job. Not only must utility response crews be concerned with the possible presence of still-energized conductors within the storm debris, but the lines and equipment are often under great physical tension. The key to minimizing the occurrence of tree contact with overhead electrical conductors is effective and regularly-performed tree trimming. A regularly and properly performed tree trimming program consistent with ComEd's actual stated guidelines, best practices, and sufficient clearance can prevent these undesirable situations.

Q: HOW SHOULD COMED ADHERE TO NESC GUIDELINES TO ENSURE A SAFE SYSTEM AND INCREASED SYSTEM RELIABILITY?

A: Best utility practices require that electrical utilities such as ComEd perform effective tree trimming on a regularly scheduled basis, usually on a three to four-year cycle, with regular maintenance inspections in between. By maintaining a three to four-year cycle ComEd would effectively be revisiting all trees adjacent to its distribution system at least every three to four years. Trees exhibiting rapid growth towards energized components of the system should be addressed on a more accelerated cycle if conditions warrant. Problems are thereby taken care of earlier, and outages caused by excessive vegetation growth are avoided. Between tree trimming cycles, inspections of pole lines should be made to determine if the required clearance requirements are being violated by aggressive tree growth or by tree damage or decay. If clearance violations are observed, ComEd must remediate them immediately to prevent unsafe conditions from developing further.

Q: CAN COMED ADHERE TO AN EFFECTIVE TRIMMING SCHEDULE AND COMPLY WITH NATIONAL AND STATE STANDARDS?

A: Yes, I believe ComEd can maintain an effective tree trimming program that complies with national and state standards. In other words, ComEd can comply with industry standards and at the same time respect local interests in protecting mature vegetation. These are not mutually exclusive principles. Property owners on whose land trees exist in proximity to overhead lines are in many cases equally concerned with the beauty and health of their trees as they are with the reliability of their electricity service. Improper and infrequent trimming of these trees will lead to unsightly and unhealthy tree conditions and dissatisfaction among residents. A necessary balance must exist. Property owners worry about the health and beauty of their trees and utilities must be concerned with continuity of electric service to customers, the safety of their crews and the public, and the cost of effective and regular tree trimming. If proper adherence to laws and standards is maintained in a consistent manner throughout its service territory, it is possible for ComEd to improve reliability for its customers and at the same time preserve mature vegetation cherished by its customers.

Q. **CAN YOU ELABORATE ON STANDARDS FOR UTILITY TREE TRIMMING PRACTICES?**

A. Both the utility industry and federal and state governments have taken steps to develop standards for the governance of utility tree trimming practices. For example, American National Standards Institute ("ANSI") standards for nursery stock stipulate that to preserve tree health, not more than 25% of a tree's biomass can be removed in any one tree trimming cycle.[8] When implementing these standards, however, it must be remembered that the objective of utility tree trimming is to ensure that minimum clear zones around energized conductors are not violated during the time period between tree trimmings. This means that the utility's tree trimming personnel must not only trim to the required minimum clearances, but must also trim the additional distances that the various species of trees will be anticipated to grow during the interval between tree trimmings. Because of varying growth rates for tree species and related trimming techniques, electric utilities should engage the services of licensed tree experts to oversee their tree trimming programs. Furthermore, during years of excessive precipitation, tree growth rates will accelerate and, therefore, tree trimming cycles will have to be adjusted to keep pace with the growth. The bottom line is that minimum clear zones around conductors must be maintained at all times.

Q: ARE THERE INSTANCES WHEN A TREE MAY NEED TO BE REMOVED?

A: Yes, there may be instances requiring removal of a tree. Trees are living organisms that age, suffer damage, and die. There is a risk that a dead or dying tree could fall into overhead lines and result in conditions that present hazards to the safe, reliable operation of overhead electric utility systems. The necessity of tree removal is often disturbing to property owners, but it is at times critical to the safe continued operation

[8] Exhibit GEO-7 (American National Standard Institute – Standard A300-2001 *Pruning*).

of the electric utility system upon which our society depends. Again, the management of this evaluation combined with an effectively scheduled tree trimming process by trained certified utility arborists, in coordination with state and local governmental agencies, are critical to the implementation of an effective tree trimming program.

Q: WHAT HAS BEEN THE EFFECT OF COMED FAILING TO ADHERE TO CONSISTENT AND ADEQUATE VEGETATION MANAGEMENT PRACTICES?

A: In my professional opinion, ComEd's failure to adhere to consistent and adequate vegetation management practices in a uniform manner has resulted in subpar reliability performance and extensive customer outage periods caused by tree damage to aerial distribution lines. This is especially true for overhead circuits along alleys and back property lines in residential regions. Had ComEd maintained a sufficient tree-trimming program in these areas, many of the outages would have been avoided or shortened. In order to restore service, much work and time was necessary to make up for the failure to maintain an effective vegetation management program.

The implementation of an effective and uniform tree trimming program after years of neglect by ComEd will now require a concerted tree trimming effort on ComEd's part. Such effort is necessary in order to ensure reliable electric service and the safety of the public. In addition, once begun, the required tree trimming schedules must be adhered to without exception. Considering that many of the reasons for service outages recorded by ComEd during storm events were due to tree contact, it is reasonable in my opinion to conclude that these outages were in most cases due to vegetation contacting energized system components.[9] Tree-related outages could have been reduced had ComEd maintained an effective tree trimming program that maintains clear zones around energized primary and secondary conductors throughout its distribution circuits. ComEd's tree trimming plan should ensure that alley and back property line circuit clearances are maintained at the same level as the electrical lines along roads and highways.

Q: YOU HAVE REFERRED TO THE NATIONAL ELECTRIC SAFETY CODE. IN YOUR OPINION DOES COMED MAINTAIN ALL OF ITS DISTRIBUTION CIRCUITS IN A MANNER THAT COMPLIES WITH THE NATIONAL ELECTRIC SAFETY CODE?

A: ComEd, in its testimony to the Illinois Commerce Commission filed November 21, 2011, stated that ComEd's entire electric distribution system conformed to applicable national standards when the summer 2011 storms occurred.[10] In my professional opinion, much of ComEd's electrical distribution system was not in compliance with the National Electrical Safety Code when the summer 2011 storms occurred.

Q: IN WHAT WAYS WERE AREAS OF THE COMED ELECTRIC DISTRIBUTION SYSTEM NON-COMPLIANT?

A: The Illinois Commerce Commission's (ICC) report on Commonwealth Edison Company Reliability Report and Reliability Performance for Calendar Year 2009 states that, "Tree conditions near ComEd's overhead distribution lines are required to meet NESC Rule 218(A)(1)." The ICC report further states that under NESC Rule

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[9] ComEd Exhibit 3.0, pg. 9
[10] ComEd Testimony to ICC for Gannon & Mehrtens - Pages 1 & 2

218(A)(1), "Trees that may interfere with ungrounded supply conductors should be trimmed or removed."[11]

My field inspections revealed that substantial areas of ComEd's distribution circuits are extensively in violation of the requirement of NESC Rule 218(A)(1)[12] and that ComEd's stated practice of providing for 10 feet of vegetation clearance and energized conditions has not been uniformly applied on all overhead lines throughout its service territory. Tree damage from storms could have been prevented if ComEd had maintained 10 feet of vegetation clearance.

Q. **DO YOU HAVE ANY CONCERNS OTHER THAN TREE CLEARANCE?**

A. Yes, I also have concerns about the total loads being placed on ComEd's distribution poles. ComEd stated in its official response to the ICC Request No. OUT 1.03 that, "ComEd's design overload criteria are based upon the NESC strength requirements for ComEd's geographic area." However, the results of our field investigations revealed many distribution pole structures that appear to be overloaded and in violation of the loading requirements stipulated by the NESC because of the multitude of additional equipment attachments actually on each pole and the small pole sizes observed in the field.[13] The results of our field inspection contradicts the Testimony of ComEd witnesses William J. Gannon and John Mehrtens who state that, "ComEd's system was designed, constructed, and maintained in accordance with

[11] ICC ComEd Reliability Report and Reliability Performance for Calendar Year 2009 – Page 15
[12] Exhibit GEO-8 (Drawings 3102, 3103, and 3104)
[13] Exhibit GEO-9 (Drawings 3105, 3106, and 3107)

good utility practice and applicable codes in June and July 2011, when storms moved through ComEd's service territory."[14]

In its data response for ICC Request No. OUT 1.03, ComEd gave the example of the NESC requirements for a Class 2, 40 foot, southern yellow pine pole with only three primary conductors and a neutral wire attached to the pole.[15] This example is not representative of the actual field conditions that exist for many of ComEd's residential distribution circuits where few poles are actually of this size and class and where most of ComEd's poles are also heavily loaded with additional secondary distribution conductors, overhead house services, and multiple telephone and CATV conductors. With regards to actual pole conditions, NESC requires certain calculations be performed to account for increased loading, and distribution circuit designs must be adjusted to account for field conditions similar to those seen on ComEd's distribution circuits. ComEd did not mention performing these revised calculations in its response to ICC Data Request No. 1.03.

Q. **DO YOU HAVE ANY OTHER CONCERNS RELATED TO DISTRIBUTION POLES?**

A. The actual field conditions within many of ComEd distribution areas revealed many poles whose strength class was not as robust as the Class 2 pole utilized in ComEd's example. Many of the poles I observed were subjected to severe overloading from a combination of secondary conductors, house services, and telecommunication cable attachments. Numerous NEC and NESC violations were also observed in residential

[14] Exhibit GEO-10 (Drawing 3108)
[15] ICC Request No. OUT 1.03 - Attachment 1: pages 1-4

backyards from inadequate secondary service heights.[16] [17] In some cases, a person -- and even a child -- could easily come in contact with overhead 240 volt service conductors by simply raising the handle of a garden rake. Distribution circuit designs and corrective actions must be carried out by ComEd to account for the true field conditions that actually exist on ComEd's distribution circuits.

Q: WHAT WOULD BE THE EFFECT OF THE CONDITIONS THAT YOU HAVE DESCRIBED UPON THE EXTENT OF STORM DAMAGE SUSTAINED BY THE COMED DISTRIBUTION SYSTEM AND THE LENGTHS OF TIME REQUIRED FOR SERVICE RESTORATION?

A: In my opinion, the failures of ComEd to comply with the vegetation management requirements of the NESC and to comply with the distribution pole loading requirements of the NESC, have exposed ComEd's distribution system to much more extensive storm related damage and to longer duration outage and restoration times than would have occurred had the requirements of the NESC been followed. Extensive encroachment by trees and resultant envelopment of distribution lines along alleys and back property lines, coupled with overloading of pole lines prior to the summer 2011 storms, severely lessened the ability of many of ComEd's distribution circuits to adequately withstand these storms. The result was that far more extensive damage was suffered by ComEd's distribution system and resulting restoration times were unnecessarily extended. Outage and service restoration times that should have been limited to a few hours were unnecessarily lengthened into days

[16] Exhibit GEO-11 (Drawings 3109, 3110, 3111, and 3112)
[17] Exhibit GEO-12 (NESC Table 232-1 and NEC Article 230)

or even a week or more in some instances.[18] [19] [20] It must be remembered that damage to utility systems from storms is a function of the severity and seasonal timing of such storms as well as the physical conditions of the utility systems before the storms struck. In the case of the summer 2011 storms, the condition and reliability of many of ComEd's distribution circuits were so compromised before the storms occurred that the resultant levels of damage and customer restoration times were far greater than if the distribution circuits had been previously maintained in conformance with industry and national standards.

B. Equipment Improvements

Q: DO YOU HAVE OBSERVATIONS REGARDING EQUIPMENT THAT WOULD HAVE IMPROVED THE ABILITY OF COMED'S DISTRIBUTION SYSTEM TO PREVENT OR SHORTEN SOME OF THE 2011 SUMMER STORM OUTAGES?

A: Yes. There are definite investments in electrical infrastructure and equipment which ComEd could have made to improve the reliability of its distribution system. These investments were needed in several areas, including distribution poles, transformers, fusing, switchgear, lightning protection, and application of system modernization technologies.

Q: WHAT ARE YOUR CONCERNS IN REGARD TO DISTRIBUTION POLES?

A: While I understand the basis of the ICC Staff's statement in its Commonwealth Edison Company Reliability Report for Calendar Year 2009 that the increasing

[18] ComEd Petition dated August 18, 2011
[19] ComEd Testimony by Cheryl M. Maletich – page 16
[20] Statements by officials in the Village of Glenview on 12/6/11, Village of Morton Grove on 12/6/11, City of Lake Forest on 12/7/11, and Village of Arlington Heights on 12/8/11

median age of the existing equipment does not by itself provide an indication of possible reduction in reliability performance, our field inspections revealed that in ComEd's case, age of the distribution poles matters greatly.[21] Our field inspections throughout a dozen cities served by ComEd revealed distribution poles and conductors in residential areas that were installed during the 1950s. It is our opinion that many of these poles are the original poles that existed within these service territory areas when they were purchased by ComEd during the 1950s as part of its territorial expansion. Many poles were observed that appeared to be fifty to sixty years of age and were severely cracked and deteriorated with lost wood and split pole tops.[22] Many of these poles also appear to be severely overloaded from attached transformers, secondary conductors, aerial service drops, and telecommunication cables. Many were observed to be leaning and with little or no guying support.[23] As noted previously, many of the poles were inadequate height and class to support the equipment attached to them and they were also enveloped by trees. As noted in the ICC report of December 31, 2010, the median age of ComEd's distribution wood poles is 41 years.[24] Thus, one-half of ComEd's poles are forty years old or older. From the results of our field investigations, I believe that easily 25% of ComEd's distribution poles are fifty to sixty years old. When wood distribution poles reach fifty years of age or more they are highly suspect of being structurally deficient from a combination of cracking, splitting, impact damages, woodpecker and insect damage, lightning strike and ground line moment degradation as a result of ground level rot.

[21] ICC ComEd Reliability Report and Reliability Performance for Calendar Year 2009 – Page 2
[22] Exhibit GEO-13 (Drawings 3113, 3114, 3115, 3116, and 3117)
[23] Exhibit GEO-14 (Drawings 3118 and 3119)
[24] ICC ComEd Reliability Report and Reliability Performance for Calendar Year 2009 – Page 2

This was verified in a study by the Oklahoma Corporation Commission of 2008, which concluded that when distribution poles reach fifty years of age, they are at the end of their life.[25] Although the actual life expectancy of a wood pole will vary depending on numerous environmental factors, the general consensus among those within the industry is for a life expectancy of typical wood distribution poles to be between thirty years and fifty years.[26] As evidenced from our field investigations, many of ComEd's poles along alleys and back property lines need to be replaced immediately! It is my professional opinion, that as many as 25% of ComEd's distribution poles require replacements immediately due to age, deterioration, and overloading. Such pole replacement would allow ComEd to correct the associated overloading, height, and vegetation problems that were observed to be affecting the existing structures. This work would afford ComEd the opportunity to address apparent transformer and conductor loading problems as well as to address the necessary clearing of rights-of-way and much need tree trimming.

Q: YOU MENTIONED APPARENT PROBLEMS WITH DISTRIBUTION TRANSFORMERS THAT WERE OBSERVED DURING THE FIELD INVESTIGATIONS. CAN YOU EXPLAIN?

A: Yes, under operating conditions that result in severe overloading such as extreme heat or high demand, pole-mounted distribution transformers can suffer overheating to the extent that the insulation oil contained within the transformers will expand and even overflow out of the affected transformers and flow down the outside of the

[25] Exhibit GEO-15 (Oklahoma Corporation Commission Inquiry into Undergrounding Electric Facilities, June 30, 2008)

[26] Exhibit GEO-16 (American Iron and Steel Institute, Steel Distribution Pole Case Study)

transformer tanks. The effects of the severe internal heat stress on these transformers during severe overloads will result in the degradation of the transformers' internal insulation and windings. Contact with the hot oil and high tank temperatures can also cause deterioration of the external paint on the transformer tanks. If overheating is repeated enough times, the external paint will deteriorate and with exposure to the weather, noticeable rusting of the transformer tank will occur. In fact, the resultant rust patterns will mimic the previous oil overflow patterns.

During my field investigations, evidence of such transformer overloading was observed at many locations similar to that which is illustrated.[27] This was also brought to our attention by municipal officials who also reported that they had been forced to respond to pole-mounted transformer fires caused by severely overloaded transformers.[28] [29]

Q: WHAT DO YOU BELIEVE TO BE THE CAUSE OF SUCH TRANSFORMER OVERLOADS?

A: In my professional opinion, many of these transformers appeared to be of similar age to the poles on which they were mounted. I believe that many of these transformers date to the early 1950s when the poles were originally installed, that is, at the time many of these residential areas were first developed. It is important to remember that typical residential electrical loads were much lower in those years compared to today. The typical residential house service capacity during the post World War II era was 60 amps. Today, residential electrical services are typically 200 amps in capacity and

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[27] Exhibit GEO-17 (Drawings 3120, 3121, and 3122)
[28] Statements by officials in the Village of Arlington Heights on 12/8/11
[29] Exhibit GEO-18 (ComEd Story in the Chicago Tribune, 10/23/11)

sometimes larger. Transformers installed during the 1950s cannot be depended upon to carry the loads demanded of them by today's residential service loads. Older homes have been modernized with electrical circuitry to carry new appliance and electronic loads, and the addition of air conditioning. Homes constructed during the last twenty years are built with central air conditioning which adds even greater electrical demand during peak times. I believe that these resultant overloads have been further worsened by the recurring hot summer weather trends witnessed in the northern areas of the United States in recent years. Undoubtedly, the extreme heat of this past summer added to the severe overload of these transformers.

Q: WHAT SHOULD BE DONE BY COMED TO REMEDY THIS PROBLEM?

A: In concert with the previously recommended pole replacement program, Com Ed should initiate a system-wide program of assessing all of its existing residential service loads and the required transformer and secondary service sizing. It is my professional opinion that many problems related to service quality are caused by aged and severely overloaded distribution transformers and their associated secondary network conductors. Many of these transformers and secondary service cables simply need to be replaced and upgraded with properly sized equipment. If this were carried out system-wide by ComEd, a vast improvement in service quality would be experienced by its residential customers.

Q. DO YOU HAVE ANY OTHER CONCERNS RELATED TO LOADING AND THE CONDITION OF THE POLES?

A. Yes. In addition, to my concern about the age and condition of a large portion of ComEd's poles, as noted in the photographs of inspected residential areas, numerous overhead residential service drops do not have sufficient clearance heights above grade to comply with the requirements of the NEC and the NESC.[30] [31] As part of its evaluation, re-design, and re-construction of residential service areas, ComEd must also evaluate the adequacy and construction of its overhead residential service drops. Service drops that are too low or otherwise improperly designed can expose the public to hazardous conditions and cause outages during storms when trees or debris come into contact with overhead energized service drops.

Q: WHAT OTHER OPERATIONAL DEFICIENCIES DID YOU OBSERVE?

A: Deficiencies were observed in the fusing of distribution primary conductors that are tapped from the main distribution circuits.

Q: PLEASE EXPLAIN.

A: Across the nation, it is standard utility practice to install fusing equipment at the points where three phase and single phase branch line conductors are connected to main distribution circuits. This practice ensures that in the event that short circuit conditions occur on the branch conductors, such as from fallen tree limbs, the fuse or fuses will melt, sectionalizing the faulted conductors from the main circuit and thereby preserving electric service to other customers served by the main circuit. The problem that we observed in many areas was a lack of adequate and uniform application of sectionalizing fusing on branching primary conductors. Field observations conducted within Glenview, Morton Grove, Elmhurst, Evanston, Highland Park, Lake Forest, Schaumburg, Arlington Heights, Rolling Meadows, and Rockford revealed inadequate branch fusing or even totally non-existent branch

[30] Exhibit GEO-11 (Drawings 3109, 3110, 3111, and 3112)
[31] Exhibit GEO-12 (NESC Table 232-1 and NEC Article 230)

fusing. In other words, as the referenced photograph illustrates, we saw many instances of unfused solid connections between three phase branch conductors and sub-branching single-phase primary lines.[32] The lack of proper fusing of branching primary conductors was further exacerbated by the fact that this was most frequently observed in highly forested residential areas which were prone to storm related outages from tree contact. These were often the same areas where little or no pre-storm tree trimming was evident.

Q. **HOW DOES THE LACK OF FUSING AFFECT THE FREQUENCY AND DURATION OF STORM OUTAGES?**

A. The coincidence of inadequate or non-existent fusing in residential areas combined with inadequate tree trimming undoubtedly contributed heavily to the magnitude and duration of the storm related outages which were experienced by these communities during the summer storms in 2011. It is also my professional opinion that this same lack of proper branch circuit fusing coupled with ineffective vegetation management presented unnecessary difficulties to utility storm response crews brought in by ComEd from outside electric utilities as they attempted to deal with widespread outages and found no apparent means of sectionalizing the damaged areas from undamaged areas. As a case in point, we observed an apartment complex for senior citizens in the Village of Morton Grove which suffered multiple days of lost electrical service in spite of the fact that the main electrical circuit which supplied service to the housing complex appeared to be totally clear of tree contact. Our field investigation, however, revealed that less than a block away, an unfused three-phase branch circuit

[32] Exhibit GEO-19 (Drawings 3123 and 3124)

existed which showed conditions of major tree related damage. This was evident from multiple aerial line splices and evidence of major recent tree trimming. It is my professional opinion that the senior citizen housing complex suffered the extended outages unnecessarily because a nearby branch circuit which passed through an area of heavy tree encroachment had not been properly fused but instead was directly bonded to the main circuit.[33] I believe that when the tree encroachment on the unfused branch circuit caused a circuit fault, the main circuit was unnecessarily de-energized and kept out of service for days resulting in extended hardship for the senior citizens nearby. Based upon my field investigations, I believe that the absence of needed fuses caused this type of occurrence to be repeated throughout much of ComEd's service territory during the multiple storms of 2011. If a uniform and consistent application of fusing for three phase and single phase branch circuit conductors was carried out by ComEd throughout its service territory, this problem would be solved and the number and duration of related outages could be significantly reduced. Installation of appropriate fusing would result in more effective sectionalizing capabilities and ultimately facilitate the restoration of electric power to main distribution circuits which is the foundation of any effective storm restoration plan.

Q: YOU REFERRED TO SECTIONALIZING ISSUES INVOLVED WITH THE EXTENDED OUTAGES EXPERIENCED BY COMED CUSTOMERS DURING THE SUMMER 2011 STORMS. DO YOU HAVE ADDITIONAL OBSERVATIONS TO PRESENT ON THE SUBJECT?

[33] Exhibit GEO-19 (Drawings 3123 and 3124)

A. In addition to inadequate branch conductor fusing, large areas of ComEd's distribution system have inadequate pole-mounted sectionalizing switchgear. When most utilities initiate storm response efforts, storm damage assessment personnel are usually initially dispatched to ascertain the extent of storm damage and available means of disconnecting or sectionalizing damaged areas from healthy circuits. A basic means of accomplishing this is through the use of already in place pole-mounted sectionalizing switchgear. While the most basic type of this equipment can be non-load breaking single phase disconnect switches, most utilities have for many decades employed three phase gang-operated load-break switches.[34] [35] The benefits afforded to operating personnel by the three phase gang-operated load-break switches are two-fold; that is, greater accessibility, and greater ease of operation. Both benefits derive from the fact that these switches provide simultaneous switching of all three phase conductors through a single operating handle mounted at the base of the distribution pole. Thus, even when extensive storm debris blocks access of utility line trucks to the site of the pole-mounted gang-operated switch, service personnel can walk to the pole base, unlock the mechanism and carry out the necessary switching while standing on the ground. By contrast, the basic hook-switch activated, single phase disconnect switches require access by a utility bucket truck properly positioned in close proximity to the pole on which the disconnect switches are mounted. Once a utility lineman is properly positioned in a bucket truck at the top of the pole near the disconnect switches, several steps must occur. First, the conductors should be de-energized back at the substation circuit breaker due to the non-load

[34] Exhibit GEO-20 (Drawing 3125)
[35] Exhibit GEO-21 (Drawing 3126)

breaker rating of these types of switches. Then, each phase must be individually switched, one at a time. This more extensive procedure involved with single phase switching requires total accessibility to the site by a utility bucket truck plus substantially more time and utility coordination to accomplish. These are exactly the reasons that most utilities across the United States adopted the use of three phase gang-operated load-break switches decades ago.

Unfortunately, our field investigations found almost no three phase gang-operated sectionalizing switches employed by ComEd throughout the regions inspected. Three days of field investigations carried out in a dozen cities revealed only two such switches. However, dozens upon dozens of single phase hook-stick operated non-load break switches were observed. This widespread use of an old style switching technology is unnecessary and greatly adds to the difficulty of and time required for service restoration after storms have damaged the system. The reliance on such outdated equipment undoubtedly lengthened the outage periods experienced by many ComEd customers during the summer 2011 storms.

Q: HAVE ADDITIONAL IMPROVEMENTS BEEN MADE TO DISTRIBUTION SWITCHGEAR TECHNOLOGY OVER THE DECADES?

A: Yes, numerous advances have been made in the development of distribution sectionalizing equipment. In fact, one of the most effective developments was first introduced to the industry some fifty years ago, with the development by the Line Material Company of the pole-mounted three phase circuit recloser. This device was literally a smaller pole-mounted version of the substation mounted circuit breaker and contained fault sensing relay control equipment that could detect conductor faults and cause the three phase recloser to open and then reclose the circuit connection multiple times when a fault occurred. These pole-mounted reclosers were found to be extremely effective by the rural electric cooperatives and were then widely adopted by utilities across the nation. Today these reclosers are manufactured by numerous companies including Cooper Power Systems, ABB, Joslyn, G&W Electric, S&C Electric, and others.[36] In normal application, reclosers are deployed at a location near the middle of a typical overhead distribution circuit. When a fault occurs somewhere on the outer regions of the circuit, the recloser can detect the faulted condition and attempt to clear the problem by opening and subsequently reclosing or re-energizing the affected length of circuit. If the faulted condition proves to be long-term and not momentary, the recloser will automatically open and de-energize the problem area while preserving the integrity of the first half of the circuit by not forcing the circuit breaker located back at the substation to operate. This capability to limit the effect of outages is precisely the reason electric utilities across the nation employ these devices to provide automatic sectionalizing for long rural circuits.

Unfortunately, the field investigations we performed in a dozen service areas of the ComEd system revealed only one (1) installation of a pole-mounted recloser for automatic sectionalizing of 4 KV and 12 KV overhead circuits. It is my professional opinion that had ComEd installed such readily available and proven equipment throughout its nearly 5,200 distribution circuits in prior years, the outages resulting from the summer 2011 storms would have had vastly reduced outage

[36] Exhibit GEO-22 (Product Cut-Sheets)

durations for many customers.[37] In fact, ComEd stated in its response to the ICC Request No. OUT 1.07 that if automated distribution technology were employed, faulted circuit sections would be automatically isolated and non-affected customers would automatically be restored. ComEd went on to say that, “at least 50 percent of the customers who were knocked out of service would be automatically restored in a matter of minutes.”[38] I question why ComEd does not have more of this well-established equipment installed on its system.

Q: HAVE FURTHER ADVANCES BEEN DEVELOPED WITH SUCH AUTOMATED SECTIONALIZING EQUIPMENT?

A: Yes, they have. Some twenty years ago, major breakthroughs occurred in the area of wire-less telemetry technology that could be integrated with available System Control and Data Acquisition (SCADA) systems. As a result, manufacturers built wireless telemetry into devices such as circuit reclosers and pole-mounted three phase load-break switches and then integrated them with SCADA systems and automated distribution restoration systems. These equipment manufacturers include such well known industry names as S&C Electric, Cooper Power Systems, ABB, Joslyn, G&W Electric, and Federal Pacific. In addition, over twelve years ago, IEEE published a major article on the rapidly developing and highly effective advances in automated distribution systems.[39]

During the same time period, other manufacturers developed a wide array of similar devices for application on underground distribution systems. The past ten

[37] ComEd Data Requests No. AG 4.06 and AG 4.07
[38] ICC Request No. OUT 1.07
[39] Exhibit GEO-22 (Product Cut-Sheets)

years has seen robust deployment of these intelligent, fast response, and self-activating devices throughout the distribution utility world.[40] Actually, the development of these technologies and their deployment with automated distribution systems by utilities over the past decade became the precursor of the highly acclaimed SMART Grid technologies discussed throughout utility press today. In fact, the concept of intelligent meters is merely a wireless or fiber optic adaptation of much earlier successes with remote meter reading technologies. To state this more concisely, the basic features of the SMART Grid, or "grid modernization," have been available at the distribution system level for most of the past twenty years. Some utilities took advantage of these smarter, more flexible, more responsive technologies within their distribution systems and some did not. It appears from our field investigations of communities greatly affected by the summer 2011 storms that ComEd chose not to proactively invest in these readily available technologies over the past several decades.

Q. **WHAT WAS THE EFFECT OF THE ABSENCE OF THESE TECHNOLOGIES?**

A. The absence of these technologies from ComEd's distribution system speaks for itself. It is my professional opinion that had these types of equipment been in place throughout ComEd's distribution circuits, many of the lengthy outages experienced by customers in the aftermath of the 2011 summer storms could have been minimized because the distribution system would have had the capability to remotely restore itself.

[40] Exhibit GEO-22 (Product Cut-Sheets)

Q: YOU DISCUSSED AVAILABLE TECHNOLOGY FOR DEALING WITH SUSTAINED CIRCUIT FAULTS CAUSED BY TREE DAMAGE. ARE TECHNOLOGIES AVAILABLE TO MITIGATE THE EFFECTS OF MOMENTARY OR INTERMITTENT TREE CONTACT WITH ENERGIZED OVERHEAD WIRES?

A: Yes, there are. One option for addressing this problem that was not extensively used prior to the storms is the installation of spacer cable in areas of high forestation.[41] A spacer cable array is essentially a grouping of three partially insulated primary cables separated by an insulated cable hanger bracket that is suspended from a high strength steel support cable which also serves as a circuit neutral conductor. Because the three primary conductors are bundled in a close array, spacer cable occupies less pole space than traditional overhead circuit construction. In addition, the partial insulation covering around the primary conductors serves to minimize short circuits caused by momentary or intermittent tree contact. Thus the use of spacer cable can allow utilities to construct overhead circuits through areas of heavy forestation with reduced tree trimming spatial requirements and reduced fuse outages caused by momentary or intermittent tree contact. The drawbacks of spacer cable installation are two-fold. First, since the steel support cable carries the weight of the entire cable array, distribution poles are subjected to highly concentrated loadings and stresses at the points of attachment of the steel support cable. This requires re-engineering of distribution pole lines previously utilized for standard open wire construction and may require the replacement of existing poles to accommodate the new loading

[41] Exhibit GEO-5 (ComEd's Report for Park Ridge-page 5)

parameters. Secondly, the use of spacer cable may lull utility crews into thinking that it eliminates the need for regular tree trimming around the spacer cable. The fact remains that tree encroachment into and around cables with spacer cable arrays can set up conditions where excessive storm damage occurs to distribution lines from falling major limbs and trees. This is due to the force of the tree impact upon the spacer cable array, which is then transferred to the poles resulting in significant damage to the structures. The other possibility is that trees falling into the spacer cable simply push the line and the attached poles over. Although spacer cable cannot be considered as a substitute for proper tree maintenance, it can be used to provide some protection against minor debris and momentary vegetation contact.

The second technology is the use of Trip Saver devices for the replacement of certain fuses in areas of high forestation.[42] Trip Saver devices are substantially more expensive than fuses and are currently available in a limited number of ratings. They are essentially miniature single phase reclosers that can be inserted into a bracket normally used for a line fuse. Whereas a fuse is a one-time device which results in a permanent disconnection of a line when it blows, a Trip Saver can provide for a single line reclosing attempt after initially de-energizing the line due to a momentary fault. The use of a Trip Saver on a previously fused branch line could eliminate the need to dispatch utility personnel for service restoration if the fault was only momentary. The drawbacks are that Trip Savers are far more expensive than traditional fused disconnects and are currently only available in limited current ratings. This technology does show promise to mitigate fuse blowing from

[42] Exhibit GEO-5 (ComEd's Report for Park Ridge-page 4)

momentary tree or animal contact of primary conductors. Again, as with spacer cable, this technology cannot be considered as a substitute for effective vegetation management.

Q. DO YOU KNOW WHETHER COMED'S DISTRIBUTION SYSTEM INCLUDED SPACER CABLES AND "TRIP SAVER" DEVICES?

A. Although my field observations did not validate the use of spacer cable and trip saver devices, many of the ComEd presentations to municipal officials included these technologies as future methods by which system reliability was proposed to be improved.

Q: ARE THERE ADDITIONAL STEPS THAT COMED COULD TAKE TO IMPROVE RELIABILITY IN HEAVILY FORESTED RESIDENTIAL AREAS?

A: Yes, there are. ComEd should evaluate the feasibility of replacing selected overhead circuits in the most forested areas with underground primary and secondary cables and pad mounted transformers. In fact, during discussions with several municipalities, they indicated that ComEd has already begun such evaluations. It is my professional opinion that ComEd should consider this option as the proper solution for many such areas across its entire service territory, subject to the evaluation of cost compared to the expense of establishing proper vegetation management in these over-grown areas. It appears that ComEd has effectively abandoned maintenance of its back property line rights-of-way in numerous communities. The re-establishment of its easements could require extensive tree trimming and disruption to the residences along the lines. Through the use of modern day directional bore techniques, it is possible to install new underground cables without great dislocation to customers.

Q: YOU HAVE MENTIONED THE INSTALLATION OF NEW UNDERGROUND PRIMARY CABLES. DOES COMED ATTRIBUTE ANY STORM OUTAGES TO UNDERGROUND EQUIPMENT?

A. Yes. ComEd attributed between 4% and 9% of its summer storm outages to underground equipment.

Q. DURING YOUR FIELD INVESTIGATIONS, DID YOU ENCOUNTER PROBLEMS WITH EXISTING UNDERGROUND CABLES OWNED BY COMED?

A: Yes. During meetings with numerous municipal officials, mention was made by these officials of citizens' problems with recurring outages from underground cable faults.[43] It appeared that these were in residential areas where primary cables had been buried during the late 1960s and 1970s. It is widely recognized across the utility industry that primary underground cables installed during these time periods are now highly suspect for needing replacement with new primary cable. This is true for two reasons. First, the polymers utilized in the production of solid dielectric primary cables during these early time periods have a general life expectancy of thirty-five years. Experimentation with polymer types and manufacturing techniques by manufacturers during that time period led to some less then desirable quality issues. The basic issue is that moisture within the underground environments is the enemy of cable life. Moisture will eventually work into the insulation at the molecular level

[43] Statements by officials in the Village of Glenview on 12/6/11, City of Lake Forest on 12/7/11, Village of Schaumburg on 12/8/11 and Village of Arlington Heights on 12/8/11

and cause microscopic short circuit paths to form from the energized primary conductor to ground. The cable industry has coined the phrase "treeing" to describe the microscopic short circuit paths that develop. Some utilities have tried remediation techniques such as the pressurized injection of nitrogen or insulating liquids into the cables in an attempt to drive the moisture out. Eventually these efforts prove futile simply because the "treeing" problems continue to occur throughout the entire length of these cables which allows moisture to re-enter through the cable insulation.

Modern materials and manufacturing techniques are definitely superior to those of the late 1960s and 1970s. Modern cables can be purchased with a fully jacketed polymer outer covering and with either high grade Cross Linked Polyethylene (XLPE) or Ethylene Propylene Rubber (EPR) insulation. Both cable types have been found to provide excellent performance characteristics and long life. The installation of such new primary cables, pad mounted transformers, and new underground service conductors to the residences would substantially improve service quality and reliability to ComEd's customers while still maintaining the homeowners' usage of their yards which would be devoid of conflicts with overhead conductors.

Q: YOU HAVE SUGGESTED SEVERAL RELIABILITY IMPROVEMENTS TO COMED'S DISTRIBUTION SYSTEM. ARE THERE ADDITIONAL AREAS WHERE IMPROVEMENTS CAN BE MADE TO PREVENT STORM DAMAGE?

A: Yes. Within ComEd's storm reports, it has presented evidence of problems resulting from high levels of lightning strikes.[44] [45] Such was undoubtedly the case with the

[44] ComEd Petition dated August 18, 2011 – page 2

storms that occurred during the summer of 2011 time period. As ComEd has testified to the ICC, the discharge current and voltage levels of these lightning strikes can be very high and the resultant damage to electrical utility systems can be substantial.

Three areas of technology are available to utilities to mitigate the damaging effect of lightning strikes. They are static shield protection of higher voltage circuits, lightning arresters, and grounding systems. ComEd is utilizing all three technologies; however, improvements to these systems can be made. In its responses to the ICC Request No. OUT 1.03, ComEd stated that, "On the 34 KV system, many lines have been built with a shield (or static) wire that is designed to "shield" the phase conductors from a direct lightning strike."[46] This is a good preventative measure, but all 34 KV, 69 KV, and 138 KV lines serving distribution substations should be protected by means of static shield wire. Our field investigations revealed numerous 34 KV lines which were constructed without this technology. Through the use of pole top bayonet extension brackets, static shield wire protection can be added to these lines at a reasonable cost, and ComEd should proceed with such installations throughout its system.[47]

The second area of technology is the deployment of lightning arresters and their maintenance. As ComEd officials have stated in their filed testimony, they have utilized lightning arresters throughout their system. Undoubtedly the summer storms of 2011 and the resultant evidence of large numbers of lightning strikes which caused system damage should yield valuable information to ComEd as to where enhanced

[45] ComEd Testimony by Cheryl M. Maletich – page 11
[46] ICC Request No. OUT 1.03
[47] Exhibit GEO-23 (Drawings 3127 and 3128)

lightning arrester protection should be applied. Not only should a greater concentration of lightning arresters be utilized in lightning prone areas, these arresters should be inspected for damage after a lightning intense storm impacts a specific service area. As ComEd has stated in its testimony, lightning arresters can be damaged by lightning strikes in close proximity to the arresters and totally destroyed by direct strikes. For these very reasons, ComEd's system of lightning arresters should be thoroughly inspected and damaged arresters replaced after each severe lightning storm. Otherwise, the assumed level of protection may have been compromised by the strikes that occurred and residents will experience repeated outages as a result of the lack of protection against lightning strikes.

The third area of technology available to all utilities is that of an effective and well-maintained grounding system. Grounding systems are some of the most important parts of a reliable distribution system with regard to its ability to provide consistent quality of service to its customers. Unfortunately, it is at the same time the most neglected part of many utility systems. The adage of "out of sight, out of mind" is totally applicable here. Because the largest part of a grounding system is buried underground, it is often assumed by utilities to have qualities that do not actually exist on a practical basis. To effectively maintain low resistance paths to the earth for the dissipation of high energy lightning strikes, lightning systems must have overhead to below grade grounding conductors that are unbroken, solidly connected and of suitable ampacity to effectively carry the discharge current from the lightning strikes to earth. In addition, the electrodes buried underground must be unbroken, of adequate size and in constant contact with the ambient water table. Nothing is more ineffective at dissipating the high energy from lightning strikes than broken, undersized grounding conductors and electrodes buried in dry earth. Such systems have the appearance of providing effective lightning protection, ready to carry and dissipate the high energy surges of lightning strikes, when in reality they may be functionally useless.

The integrity of grounding systems is equally important for a utility in maintaining stable distribution system operation and stable voltage delivery to customers. An axiom that is often taught to young utility engineers is that at the root of many and varied electrical system problems is a poor grounding system. I have lost count throughout my thirty-eight year career of how many times this proved to be the case. Many times utility crews overlook the grounding system as being a source of their problems.

Because of the large incidence of high energy lightning strikes from summer storms, ComEd should undertake extensive inspection and testing of its grounding systems on distribution circuits as well as within substations throughout its service territory. Many utilities throughout the nation have experienced widespread problems with the weakening of grounding systems through the theft of copper conductors. In some instances, utilities have suffered the cutting and removal of every pole grounding conductor along an entire circuit length from such vandalism. Utilities have even experienced thieves breaking into substations, cutting and removing main substation transformer neutrals and grounding conductors as well as switchgear and structural grounds. This problem has reached epidemic proportions nationwide, and the only effective answers to the problem are consistent and routine inspection programs and immediate replacement of any components found to have been removed.

It must be remembered, however, that age, moisture, and soil chemistry can also lessen the effectiveness of grounding systems through corrosion of connections and bonding surfaces. Corrosion causes high resistance to occur at critical points of connection in the grounding system and reduces its effectiveness. Lastly, a grounding system's contact with the local water table can be reduced or lost through years of drought and through the withdrawal of large volumes of water from aquifers by regional wells. With population growth, some areas have experienced dramatic lowering of regional water tables over the past quarter century due to the high rate of municipal and suburban water demand. Some water tables have been observed to have fallen below thirty feet. Any loss of effective contact with the regional water table will greatly increase the resistance to earth of the distribution grounding system which will reduce the effectiveness of the grounding system.

ComEd has stated that they do not test for ground resistance.[48] However, in my professional opinion, they should. Fluctuations in the ground water table can adversely compromise the effectiveness of a utility's grounding system. The only solution to these problems is a comprehensive program of on-site field testing of grounding system to earth resistance levels throughout ComEd's service territory. This is especially important at the specific locations of lightning arrester placements on the 138 KV, 69 KV, 34 KV, 12 KV, and 4 KV systems. When abnormally high ground to earth resistance levels are found at specific locations, longer multi-section

[48] ComEd DRR to AG 3.05

ground rods and even multiple rods should be driven until acceptable ground to earth resistance levels are obtained, usually 5 ohms. The verification of and, if necessary, the re-establishment of appropriate ground to earth resistance levels at the locations of system lightning arrester installations is critical to the effective operation of any lightning protection system.[49] Inspections of these critical grounds should also be performed as a part of routine post-storm inspection programs.

Q: YOU HAVE PREVIOUSLY REFERRED TO SYSTEM MODERNIZATION TECHNOLOGIES THAT WOULD BE USEFUL IN IMPROVING DISTRIBUTION SYSTEM RELIABILITY. DO YOU HAVE RECOMMENDATIONS PERTAINING TO THESE TECHNOLOGIES?

A: Yes, the rapid development of system modernization technologies over the past decade has brought a significant number of tools to virtually every area of utility operation. At the foundational level, advances in sensory monitoring equipment as well as telecommunication technologies have extended the reach, sensitivity, and control of already existing electrical utility SCADA systems. The addition of wireless and fiber optic telecommunication technologies to the application of mid-circuit reclosers and load break switches greatly enhances the reach and effectiveness of existing SCADA systems for distribution control. When digital three-phase intelligent relays are installed in all of ComEd's distribution circuit breakers, the full capabilities of automated distribution management and automated outage management can be achieved. ComEd should move forward aggressively to implement these technology enhancements throughout its distribution system. If

[49] Exhibit GEO-24 (Grounding 101)

these technologies are implemented on a system-wide basis by ComEd, all of its customers would see major improvements in both the effectiveness of ComEd's storm response program and in the level of general system operation.

Q: APPROXIMATELY HOW MANY OF THESE DEVICES SHOULD COMED DEPLOY THROUGHOUT THEIR DISTRIBUTION SYSTEM?

A: Virtually every overhead distribution circuit could benefit from a mid-circuit recloser that is SCADA monitored and controlled. This concept was basically stated by ComEd in its response to ICC Request No. OUT 1.07.[50] Similarly, one to two SCADA controlled load-break switches installed on each overhead distribution circuit would further enhance system operation and storm outage response. ComEd has nearly 5,200 4 KV and 12 KV distribution circuits throughout its service territory and has stated in its testimony that approximately one-half are overhead circuits and one-half are underground. It can be concluded, therefore, that adequate storm hardening consistent with standard utility practice would have required approximately 2,600 mid-circuit reclosers and 3,000 to 4,000 SCADA controlled load-break switches on ComEd's overhead 4 KV and 12 KV circuits. Currently, ComEd has approximately 1,600 mid-circuit reclosers on approximately 5,200 circuits but it has not identified the use of any SCADA controlled load-break switches on its 4 KV and 12 KV distribution circuits.[51] Because similar devices are now available in pad-mounted versions, equal numbers of these devices should be installed on ComEd's underground circuits. The same practical logic is true for ComEd's approximately 5,200 distribution circuit breakers. The installation of a digital three-phase intelligent

[50] ICC Request No. OUT 1.07
[51] ComEd DRR to AG 4.22

SCADA controlled relay on each distribution circuit breaker would enable the full application of automated distribution and automated outage management systems by ComEd. In other words, approximately 5,200 intelligent digital relays should be deployed by ComEd as well, and all of ComEd's distribution substations should be converted to fully utilize intelligent or "SMART" technologies.

Q: DO YOU THINK THAT THE ABSENCE OF DIGITAL METERS CONTRIBUTED TO THE NUMBER AND DURATION OF THE SUMMER OUTAGES?

A: No. The development of intelligent digital meters and intelligent electronic devices for the control of customers' loads will ultimately contribute to the operational efficiency and reliability of distribution systems such as Com Ed's. It must be remembered, however, that the installation of intelligent meters and intelligent residential load controls will only improve service reliability for customers if the distribution circuits themselves are made reliable first. Intelligent meters and intelligent load controls are applied at the extreme ends of the distribution circuits. Improvement of system reliability for the customer must be first accomplished by the utility through reliability improvements on the transmission, substation, and distribution systems which actually deliver power to the customers' properties. ComEd should direct its major efforts at system reliability improvement toward those tasks that will bring the greatest level of improvement to all customers on a system-wide basis in the most economical and timely manner possible. Intelligent meters and intelligent residential controls should be implemented last after the other system improvements are accomplished.

Q: COMED, IN ITS PETITION FOR WAIVER, STATED THE FOLLOWING:

"The resulting interruptions were not caused by any omission or defects in ComEd's distribution system, but were unpreventable consequences of the summer 2011 storm systems. Com Ed could not reasonably and prudently have prevented the damage to its distribution system caused by the summer 2011 storm systems, or the resulting interruptions. Any actual damages incurred by ComEd's customers, municipalities, counties, or other local governments as the result of electric service interruptions in the wake of the summer 2011 storm systems were the result of that extreme weather system, and not because of any action that ComEd took or improperly failed to take, and the damage caused by the summer 2011 storm system was not preventable by ComEd."[52]

DO YOU AGREE WITH THIS STATEMENT?

A: No, I do not agree with this statement.

Q: PLEASE EXPLAIN.

A: During most years, the states which border or are in proximity to the Great Lakes experience storms with strong winds and lightning. These are not unforeseen occurrences but instead have a high degree of probability of occurring during each summer season. Some years have more storms, some years have fewer, but strong summer storms are a reasonably predictable occurrence each year in the upper mid-west region near the Great Lakes. ComEd is well aware that strong summer storms can impact their service territory in any given year and that prudent steps must be taken to adequately prepare for such events. Because of this knowledge, ComEd has

[52] ComEd Petition dated August 18, 2011

developed storm response procedures, trained personnel for storm response, and developed contractual relationships with outside contractors and neighboring utilities for support with personnel, materials, and equipment to deal with the predictable occurrences of summer storms. These are prudent actions for preparing for foreseeable events. Unfortunately, to the detriment of its customers, ComEd chose not to prudently and properly prepare its infrastructure system for the known effects of such weather events.

Q. DO YOU AGREE WITH COMED'S WITNESS THAT THE 2011 SUMMER STORM OUTAGES COULD NOT BE THE RESULT OF POOR MAINTENANCE?

A. No. This statement is blatantly untrue. Each of the maintenance items and distribution upgrades which I discussed in the previous questions were available to ComEd, and could have easily been applied by ComEd to its distribution system throughout the last twenty years. My field investigations revealed a major lack of proper vegetation management and necessary system upgrades that if accomplished would have prevented a lot of the suffering experienced by ComEd's customers. Inspection of numerous alleys and most back property line areas revealed years of neglect of adequate vegetation management in the vicinity of overhead primary lines. Numerous areas revealed extensive envelopment of lines by trees. Aged poles and transformers dating back to the 1950s were observed. Broken crossarms, leaning poles, and split pole tops were also observed. Inadequate or non-existent fusing of branching tap lines was extensive. Antiquated or non-existent sectionalizing switchgear was the norm. Incomplete static shield protection was observed on 34 KV lines in areas that sustained high volumes of lightning strikes. Overhead primaries had not been placed underground in areas obviously needing such action. Reports of existing fault-prone underground primaries were numerous. A lack of effective system-wide SCADA monitoring and control of the distribution system was evident, all of which contributed to the resulting need for more storm response manpower, more difficult reconnections, and longer outages.

Industry-wide information and equipment to prevent the kind of storm damage experienced by ComEd customers have been readily available to ComEd over the past twenty years. ComEd chose instead to not take effective and consistent action when the cumulative effects of weakened systems, inadequate sectionalizing and communication equipment and predictable summer season storms have resulted in storm outages that could have been prevented by adequate maintenance and modernization efforts. This ultimately predictable outcome should have been readily apparent to ComEd's planners and managers.

Q. **HOW DO YOU RESPOND TO COMED'S ARGUMENT THAT FEWER THAN 30,000 CUSTOMERS WERE AFFECTED BY EACH SERVICE INTERRUPTION?**

A. ComEd, in its Petition for Waiver and Direct Testimony, has tried to prove that the large number of customer interruptions and the long duration of outages that occurred were the result of a random set of unrelated events that caused uniquely separate interruptions. In other words, ComEd has tried to say that there was not a single underlying root cause. This is not true. The singular root cause for the very large number and very long duration of outages experienced by ComEd's customers is clear and evident neglect of its distribution facilities over the past twenty years.

Q. **CAN YOU GIVE AN EXAMPLE OF HOW LACK OF PROPER MAINTENANCE AND MODERNIZATION CAUSED INCREASED OUTAGE FREQUENCY AND DURATION?**

A. The results of neglect were never more evident that in the City of Lake Forest in Lake County. Two separate storms left the City of Lake Forest almost totally without electrical service for essentially an entire week during each of the storm events. Homes were without power, City services were without power, the fire station was without power, and the traffic signals throughout the City were without power resulting in traffic backups that stretched for miles through the community.[53] This was horrible for the City and its residents to endure, and it was unconscionable. Lake Forest did not suffer Hurricane Andrew as the City of Homestead, Florida did in 1992 or Hurricane Camille that struck the City of Gulf Port, Mississippi in 1969. Instead, it suffered only a few summer thunderstorms, but the effects were substantial. And Lake Forest was not alone. Numerous communities reported similar issues to the Attorney General's Office pertaining to the 2011 summer storms.

The root cause for the number of outages experienced as well as the extent of system damage incurred, and the duration of system outages experienced by ComEd from the summer 2011 storms is the neglect of the ComEd distribution system. Furthermore, the large number of outages, the extent of system damage, and the

[53]Statement by City officials in the City of Lake Forest on 12/7/11

duration of system outages were largely preventable by ComEd if they had accomplished the necessary vegetation management and prudent system upgrades.

Q. IS IT POSSIBLE FOR COMED TO PREVENT SUCH EXTENSIVE OUTAGES?

A. In my professional opinion, proper investment and maintenance could have greatly limited the number of outages, the large number of people affected, and minimized the duration of outages experienced. In order for ComEd to provide substantial and lasting improvements to the reliability and storm readiness of its distribution system, the following improvements should be made throughout its entire service territory in the priority listed so that <u>all</u> customers will benefit equally and in a timely manner:

1. Implementation of a uniform and effective vegetation management program.
2. Replacement of aged and overloaded poles and transformers.
3. Implementation of a uniform and effective branch circuit fusing program.
4. Installation of SCADA controlled three phase mid-circuit reclosers on all distribution circuits.
5. Installation of SCADA controlled three phase load-break disconnect switches on all distribution circuits at critical sectionalizing locations.
6. Replacement of many single phase disconnect switches with gang-operated three phase load break switches.
7. Inspection of all lightning arresters and replacement of damaged units.
8. Inspection and testing of grounds at all lightning arrester locations.
9. Repair and upgrading of all defective or under-performing grounds.

10. Installation of static shield conductors on all high voltage circuits which supply power to distribution substations and large power customers.
11. Replacement of existing overhead lines in areas of dense forestation with underground conductors and pad-mounted transformers.
12. Replacement of aged and fault-prone underground conductors with new totally jacketed underground conductors.
13. Trip Saver fuse replacements at appropriate single phase branch circuit locations.
14. Installation of digital intelligent relays on all distribution circuit breakers.
15. Implementation of system-wide automated distribution management technologies.[54]
16. Implementation of system-wide automated storm restoration technologies.

Q: DO YOU HAVE A FINAL RECOMMENDATION FOR THE COMMISSION?

A. Yes. I recommend that the Commission open an investigation to determine the state of ComEd's storm readiness and to produce a plan for effective storm hardening investments.

Q: DOES THIS CONCLUDE YOUR TESTIMONY?

A: Yes it does.

[54] Exhibit GEO-25 (*The Rise of Smart Circuits-Josh DiLuciano, Avista Corp.*, Transmission & Distribution World, December 1, 2011)